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AUTHOR	Wolff, Peter; And Others
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ABSTRACT

The generation of dynamic mental imagery is known to facilitate paired associate (PA) learning in older subjects. Wolff and Levin (in press) have reported that children who were apparently too young to generate mental imagery of this kind did benefit from self-generated motoric interactions involving pairs of toys. Since the result was obtained whether or not the child could see the objects he was manipulating, it was interpreted as supporting Piaget's contention that imagery production in the pre-imagery child requires the internalization of motor actions. In the present study, we examined the child's ability to generate memory-enhancing interactions between object pairs when either visual contact with the objects, tactual contact, or both were absent. The PA performance of each of these activity groups (Visual-tactual, Visual-No Tactual, No Visual-Tactual, and No Visual-No Tactual) was compared with corresponding control groups which received imagery instructions, but had no opportunity to manipulate the object pairs. Rated quality of overt manipulation was lowered by the absence of tactual contact with the objects, but not by the absence of visual contact. Quality of manipulation was positively related to amount of facilitation of PA performance. These results support the involvement of overt activity in the young child's imagery production and learning, and also demonstrate the kindergarten child's inability to produce ongoing thematic activity when this activity is physically separated from the objects involved. (Author)

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Technical Report No. 205

MOTORIC MEDIATION IN CHILDREN'S PAIRED-ASSOCIATE LEARNING: EFFECTS OF VISUAL AND TACTUAL CONTACT

By Peter Wolff, Joel R. Levin, and Ellen T. Longobardi

Report from the Project on the Role of
Stimulus-Correlated Motor Behavior in Children's Perception
and
the Project on Verbal and Visual Components of Children's Learning

Wisconsin Research and Development
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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Project on Variables and Processes in Cognitive Learning in Program 1, Conditions and Processes of Learning. General objectives of the Program are to generate knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

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Abstract

The generation of dynamic mental imagery is known to facilitate paired-associate (PA) learning in older subjects. Wolff and Levin (in press) have reported that children who were apparently too young to generate mental imagery of this kind did benefit from self-generated motoric interactions involving pairs of toys. Since the result was obtained whether or not the child could see the objects he was manipulating, it was interpreted as supporting Piaget's contention that imagery production in the pre-imagery child requires the internalization of motor actions. In the present study, we examined the child's ability to generate memory-enhancing interactions between object pairs when either visual contact with the objects, tactual contact, or both were absent. The PA performance of each of these activity groups (Visual-Tactual, Visual-No Tactual, No Visual-Tactual, and No Visual-No Tactual) was compared with corresponding control groups which received imagery instructions, but had no opportunity to manipulate the object pairs. Rated quality of overt manipulation was lowered by the absence of tactual contact with the objects, but not by the absence of visual contact. Quality of manipulation was positively related to amount of facilitation of PA performance. These results support the involvement of overt activity in the young child's imagery production and learning, and also demonstrate the kindergarten child's inability to produce ongoing thematic activity when this activity is physically separated from the objects involved.

I
Introduction

Several studies have demonstrated the marked facilitative effect of imagery production on paired-associate learning in adults (Bower, in press; Yuille & Paivio, 1968) and children (Wolff & Levin, in press). This facilitation, found for both concrete noun and picture stimuli, results from instructions to *Ss* to form a mental image in which the members of each pair interact in some way. The development in children of the ability to generate and manipulate mental images has been the subject of a number of investigations and theoretical discussions by Piaget. He has claimed that the ability to produce dynamic mental images, emerging at approximately seven years of age during the preoperational period, requires the "internalization" of overt motor acts (Piaget, 1962; Piaget & Inhelder, 1967). These internalized actions are analogous to mental operations, but do not have the same structural integrity as concrete or formal operations.

While this theory of imagery production is appealing, until recently no direct evidence has been produced to substantiate it. Wolff and Levin (in press), using children's toys as stimulus materials, found that while the paired-associate recognition performance of eight-year-olds was facilitated by imagery instructions, the performance of five-year-olds was not. It was therefore inferred that children under approximately seven years of age could not form the necessary interactive imagery.

However, in a second study reported by Wolff and Levin (in press), two groups of five- and six-year-olds were given imagery instructions but one group was also instructed to make the toys interact behind a screen. The actual interactions of the pairs were invisible to *S*. The paired-associate performance of this group was facilitated relative to *Ss* who held the toys but were not permitted to manipulate them. Percentage facilitation was approximately the same as that for a manipulation group which had visual access to the stimuli in the first study (54% and 61%). The recognition data, as well as *Ss'* verbal reports, suggested that *Ss'* motor activity resulted in concurrent visual imagery, which facilitated paired-associate performance. Piaget's contention that the ability to produce dynamic imagery evolves from the child's motor activity was thus supported.

Our purpose in the present study, besides providing a replication of the previous results, was to define the sensory inputs necessary for young children's production of meaningful thematic activity, with its resulting facilitation of paired-associate performance. Specifically, we examined the effects of disrupting *S*'s haptic and/or visual contact with the stimuli on (a) *S*'s ability to form appropriate motor interactions between the members of the object pairs and (b) the degree of facilitation of paired-associate performance resulting from this overt manipulation.

II
Method

Subjects

Ninety-six children, 46 males and 50 females from six kindergarten classes of a middle-class elementary school in the Midwest, served as *S*s. Their mean age was 6 years 1.2 months, with a standard deviation of 4.4 months. The largest mean age difference between experimental groups was 1.3 months. Males and females were approximately equally represented in each of the conditions described below.

Materials

The objects to be paired were 24 common children's toys, e.g., a stuffed felt giraffe, a toy wristwatch, a plastic bear, a wooden block, a plastic truck, etc. All toys were representational and easily labelable by *S*s. They varied in size from 1 to 6 in. on the widest dimension. None of the toys had mechanical moving parts.

Two lists of paired toys were constructed. One list (A) was formed by randomly pairing the 24 toys, forming 12 pairs. A second list (B) was then constructed by randomly recombining the 12 stimuli and 12 responses of the first list.

During the experiment, the stimulus and response toys were kept in separate boxes. The raised lids of these boxes prevented *S*s from seeing the toys until they were presented in the learning task.

In half the conditions, a screen was used to prevent *S* from seeing the toys. This "house" was constructed from a cardboard box, 20 in. long, 10 in. wide, and 12 in. deep, and painted flat white. The lower half of the front of the box was removed and replaced with a cloth curtain. The back of the box was also removed so that *E* could observe *S*'s actions.

Procedure

Eight experimental conditions were created by the factorial combination of three bi-level variables: visual contact (present-absent); tactual contact (present-absent); and manipulation (manipulate-control). In the Manipulate conditions, *S*s were told to "make the two toys do something together and at the same time try to make up a picture in your head of what the toys are doing together." In the Control conditions, *S*s were instructed to "make up a picture in your head of the two toys doing something together," but were not permitted to manipulate the toys overtly.

The procedures for the eight conditions were as follows:

Visual-Tactual (VT)—The *S* both held and looked at the toys, one in each hand while either causing them to interact (Manipulate) or else attempting to imagine them interacting (Control).

No Visual-Tactual ($\bar{V}T$)—The *S* held the toys, but, after looking at them briefly, took them through the curtain into the "house." Still holding the toys, *S* either caused them to interact (Manipulate) or attempted to imagine them interacting (Control).

Visual-No Tactual ($V\bar{T}$)—The *S* looked at the toys, but could not touch them. The *S* then either pantomimed an interaction by moving his hands as if they contained the toys (Manipulate) or attempted to imagine the toys interacting (Control).

No Visual-No Tactual ($\bar{V}\bar{T}$)—The *S* looked at the toys briefly, and then took them into the "house," where *E* quickly took them from *S*'s hands. The *S* then either pantomimed an interaction (Manipulate) or imagined one (Control) with the toys removed from view.

Each *S* was tested individually by two *E*s. One presented all objects to *S*, while the other handed the toys to *E*-1 and recorded *S*'s responses on the test trials.

After *S* was seated, the procedures to be followed during both study and test were explained. Each part of the instructions was illustrated with an example, using toys which were not used during the actual task. After the instructions, *S* was given a second example. *S*s in all eight conditions were shown possible interactions with each of the practice pairs. All *S*s appeared to understand the requirements of the task.

Following the practice trials, each of the 12 experimental pairs was presented for approximately 7 seconds, with a 1-second interval between pairs. Duration of presentation was timed by *E*-1 counting to himself and was occasionally checked against a watch by *E*-2.

After all the pairs had been presented, *S*s were tested by the recognition method. The 12 response toys were arrayed in front of the child, while the stimulus toys were displayed one at a time. The *S* was required to hand *E* the response toy with which the stimulus toy had been paired. After *S*'s choices were recorded, the selected toy was returned to its position in the array. No feedback was provided regarding the correctness of *S*'s choice. If *S* did not respond within 7 seconds, an incorrect response was scored and the next stimulus toy was presented. Order of presentation of test stimuli was randomly determined for each list, but was constant within each list.

For each *S* in the Manipulate conditions a rating on a 0 to 3 scale was made of the overall quality of the pairwise interactions produced by *S*. A 3 was given if appropriate interactions were generated for each of the 12 pairs. An appropriate interaction was defined as one which (a) had thematic content and (b) was applicable to the objects involved. A 0 rating indicated that no appropriate interactions had been generated for any of the pairs. Ratings of 1 or 2 indicated performance between these extremes. The interactions produced by *S*s in both the Tactual and No Tactual conditions were rated in this manner. In the No Tactual conditions the ratings were of *S*'s pantomimed interactions. Ratings were made for each *S* by *E*-1 and recorded before the recognition test was administered. In a few cases, *E*-2 disagreed with the recorded rating. These disagreements were resolved by consensus after testing was completed for that *S*. Although both *E*s knew which condition *S* was in before the rating was made, prejudicial bias in the ratings is unlikely since we had no prior hypotheses concerning the effects of the various conditions on *S*s' ability to form interactions between the object pairs.

Equal numbers of *S*s received each list under each of the experimental conditions. A random order of list presentation was followed, with the eight conditions presented in a fixed order within each list. Thus, each octet of *S*s represented a replication of the experiment within the same list.

III
Results

Recognition Performance

Mean number of correct responses for manipulation and control *S*s are shown in Figure 1 for the various conditions of tactual and visual contact. Analysis of variance showed that visual contact improved performance, $F(1, 88) = 17.56$, $p < .001$, as did tactual contact, $F(1, 88) = 9.76$, $p < .005$. Actual manipulation facilitated performance compared with imagery instructions alone, $F(1, 88) = 18.86$, $p < .001$. There was, however, a significant interaction between tactual contact and manipulation, $F(1, 88) = 13.94$, $p < .001$, indicating that manipulation was relatively more facilitative when tactual contact was present (4.42 items) than when it was absent (.34 items). No other effects were significant at the .05 level.

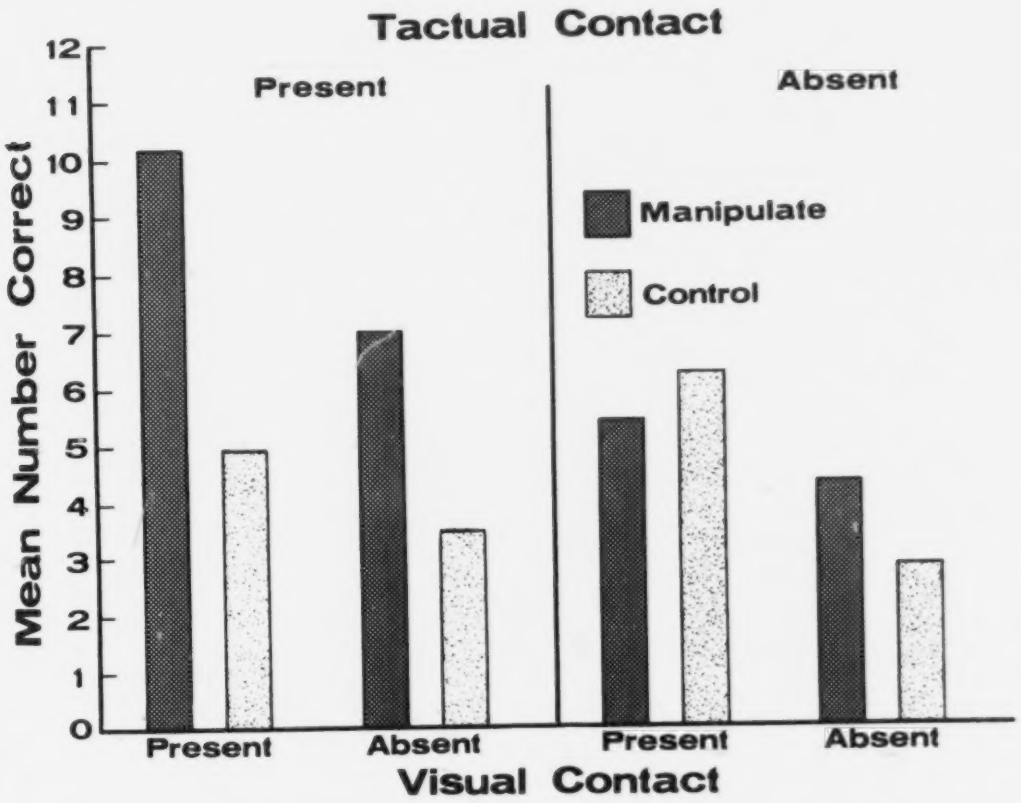

Fig. 1. Mean recognition scores for Manipulate and Control conditions under four combinations of visual and tactual contact.

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Manipulation Ratings

Analysis of mean manipulation ratings under the four visual-tactual combinations showed that better interactions were generated with tactual contact (a mean rating of 2.58) than without (1.58), $F(1, 44) = 16.67$, $p < .001$. No significant effects were found for visual contact, or its interaction with tactual contact.

Pearson product-moment correlations were computed between manipulation ratings and recognition scores. These correlations were .149, .192, .387, and .534 for the VT, $\bar{V}T$, $V\bar{T}$, and $\bar{V}\bar{T}$ conditions, respectively. The average coefficient, based on Fisher transformations, was .325, $p < .025$. It should be noted that the highest correlations were found in the No Tactual conditions ($ps < .11$ and .04 for the $V\bar{T}$ and $\bar{V}\bar{T}$ conditions, respectively).

IV
Discussion

When pre-imagery children were allowed tactual contact with the stimulus materials (VT and $\bar{V}T$), the overt formation of interactions between the object pairs facilitated recognition performance more than when tactual contact was not permitted. Percent facilitation (i.e., the difference between Manipulate and Control, relative to Control) averaged 104% in the two tactual conditions, as compared with 20% in the two nontactual conditions. Furthermore, replicating the Wolff and Levin (in press) results, percent facilitation in the tactual conditions was almost the same when visual contact was absent as when it was present (100% and 108%, respectively).

As was indicated earlier, the presence of manipulation, touch, and vision each contributed a significant main effect to the recognition data. Table 1 shows the separate effects of tactual and visual contact under both the Manipulate and Control conditions.

Table 1. Net Effects of Tactual and Visual Contact in the Manipulate and Control Conditions

	Manipulate	Control
Tactual Present minus Tactual Absent	3.75	-0.33
Visual Present minus Visual Absent	2.17	2.42

Examination of the rows of Table 1 reveals that while tactual contact facilitated performance in the Manipulate conditions, it did not in the Control conditions, in which *Ss* were given imagery instructions without the opportunity for overt activity. Visual contact, however, facilitated performance approximately equally in both conditions. These data help to clarify the previously noted Manipulate by Touch interaction and Manipulate by Vision noninteraction, respectively.

Examination of the columns shows that while tactual contact was relatively more important when *Ss* were producing interactions, visual contact was relatively more important in the Control conditions, in which *Ss* were attempting to form interacting imagery without concurrent activity.

Overt manipulation facilitated recognition performance only when *Ss* were touching the toys. Also, when tactual contact was lacking, the generation of meaningful interactions was substantially hindered. The lack of facilitation in the $V\bar{T}$ and $\bar{V}\bar{T}$ conditions was apparently caused by the failure of *Ss* in these conditions to generate appropriate interactions, rather than a failure to remember the interactions which were formed. The correlation between mean amount of facilitation from overt manipulation relative to covert imagery production and the mean manipulation ratings over the four combinations of visual and tactual contact is .997, $df = 2$, $p < .005$. This figure, together with the significant correlation between manipulation ratings and recognition scores within conditions, substantiates the conclusion that the overt activity functioned as an "elaborator" (Rohwer, 1967) in the paired-associate task.

Of considerable interest is the finding that effective activity was inhibited by lack of tactual contact, but not by visual deprivation. Qualitatively, as well as quantitatively, there were no detectable differences in the interactions produced by *Ss* in the VT and $\bar{V}T$ conditions. If a particular interaction was commonly produced when visual contact was

available, it also tended to be produced when Ss were operating "blind." Children in the $V\bar{T}$ and $\bar{V}\bar{T}$ conditions were told to form interactions as if they were holding the toys in their hands. This physical dissociation from the actual objects disrupted S's manipulative activity. This was especially true in the $V\bar{T}$ condition, which received the lowest manipulation rating. In this condition, Ss actually saw the toys while they were attempting to pantomime an interaction. In a sense it represents a misinformative feedback situation, since any dynamic image which might be produced by ongoing activity was countered by the visually salient stationary objects. This disruption of feedback may have in turn disrupted the ongoing activity.

The difficulty Ss of this age have in producing meaningful interactions without tactual contact with the actual objects is somewhat analogous to the difficulty they have in generating a dynamic image without actual movement. In each case they are unable to imagine part of a continuous integrated behavioral act: in the former, the physical involvement of the to-be-manipulated objects mediated by tactual contact, and in the latter, the dynamic interaction formed by manipulation of the objects. As development progresses, parts of the physically immediate and overt behavioral sequence can be replaced by imagery without sacrificing its psychological effects.

In reference to Piaget's developmental theory, this progression at the perceptual level bears certain striking similarities to the more protracted progression from the sensorimotor stage to the stage of formal operations at the conceptual level. The structures of intelligence in the sensorimotor child are reflected only in the actual motor sequences performed by the child on the physically immediate environment. The operations of the concrete operational child are internalized motor acts, but again can be applied only to the physically immediate environment. Finally, at the stage of formal operations, the operational structures can be applied to abstract, nonpresent entities, which can themselves be operations (Piaget, 1950). Thus, there is a progressive internalization of operations in both the perceptual and conceptual realms. The results of Wolff and Levin (in press) and the present study support Piaget's claim that these perceptual capabilities develop much more rapidly than the operational structures, and reach maturity in the preoperational period at approximately seven years of age.

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